Journal of Behavioral and Experimental Finance 30 (2021) 100477

Contents lists available at ScienceDirect

Journal of Behavioral and Experimental Finance

journal homepage: www.elsevier.com/locate/jbef

Full length article

Immune or at-risk? Stock markets and the significance of the COVID-19 pandemic

Niall O'Donnell, Darren Shannon *, Barry Sheehan

University of Limerick, Ireland

ARTICLE INFO

Article history:
Received 29 September 2020
Accepted 9 February 2021
Available online 18 February 2021

Keywords:
COVID-19
Equity index prices
Financial markets
International markets
Investor sentiment
Volatility

ABSTRACT

The closure of borders and traditional commerce due to the COVID-19 pandemic is expected to have a lasting financial impact. We determine whether the growth in COVID-19 affected index prices by examining equity markets in five regional epicentres, along with a 'global' index. We also investigate the impact of COVID-19 after controlling for investor sentiment, credit risk, liquidity risk, safe-haven asset demand and the price of oil. Despite controlling for these traditional market drivers, the daily totals of COVID-19 cases nevertheless explained index price changes in Spain, Italy, the United Kingdom and the United States. Similar results were not observed in China, the origin of the virus, nor in the 'global' index (MSCI World). Our results suggest that early interventions (China) and the spatiotemporal nature of pandemic epicentres (World) should be considered by governments, regulators and relevant stakeholders in the event of future COVID-19 'waves' or further extreme societal disruptions.

1. Introduction

COVID-19 originated in China in late 2019 and was declared as a global pandemic by the World Health Organisation on March 12th 2020 (WHO, 2020a). The current outbreak of COVID-19 has arguably been the greatest health crisis, to date, of the 21st century, prompting travel restrictions, stay-at-home orders and an unprecedented shutdown of global commerce. As of September 28th 2020, global cumulative cases stood at 33,178,019 with 998,784 recorded deaths, amounting to a fatality rate of approximately 3.5% (ECDC, 2020). From Table 1, it can be seen that although the virus is not significantly more fatal than preceding viral outbreaks, the transmission rate of COVID-19 is currently estimated to be substantially higher.

With this higher rate of transmission, the economic impact has been notably more severe relative to past outbreaks. On March 12th 2020, both the Dow Jones and S&P 500 experienced their worst trading days since Black Monday of 1987, falling over 9% and subsequently hitting 52-week lows (Stevens et al., 2020). However, large stock market losses were accompanied by similarly large upward movements throughout March, as markets reacted turbulently to developments in the outbreak, among other market factors. Table 2 illustrates the reaction of the S&P 500 and the peak-to-trough price movement of the index during recent major viral outbreaks. Table 2 highlights COVID-19 as the most significant outbreak to affect financial markets this century, by a substantial margin.

In this study, we undertake a number of multiple linear regression analyses to investigate the relationship between growth in COVID-19 and stock market index prices across a number of regions. We include data from December 2019 to June 2020, which encapsulates the exponential rise in COVID-19 cases and the subsequent 'flattening' of the infection curve (Fig. 1). The regions we include are China, Italy, Spain, the United Kingdom, the United States, and an index measuring the global impact of COVID-19. We utilise a multiple linear regression analysis as it models the linear relationship between a number of potentially-influential independent variables and a specific dependent variable. This makes it suitable to analyse whether growth in COVID-19 itself was significantly associated with index prices, using the total number of COVID-19 cases and a selection of theoretical market determinants as control variables.

The manner through which COVID-19 affected equity markets can be attributed to a conglomeration of market factors. Trading volumes and subsequent volatilities spiked to levels not seen since 2008 (Baker et al., 2020). Gold and oil markets may have served as flight-to-safety assets (Corbet et al., 2020), warranting their inclusion, while fixed-income markets underwent significant turbulence (Schrimpf et al., 2020). External market factors may have exacerbated proceedings — the tension in global oil markets between Saudi Arabia and Russia, for example, may have propagated the distress of an already volatile market (Ashraf, 2020).

A number of studies have emerged in the first quarter of 2020 examining the impact of COVID-19 on financial markets.

* Corresponding author.
E-mail address: Darren.Shannon@ul.ie (D. Shannon).

https://doi.org/10.1016/j.jbef.2021.100477

Table 1
Fatality and transmission rates of major viral outbreaks. The fatality rate of COVID-19 is not significantly higher than previous outbreaks. However, current estimates of the transmission rate (R0) indicate as many as 5.7 cases generated for each new case.
Source: [1] WHO (2003), [2] Dawood et al. (2012), [3] WHO (2019), [4] WHO (2020b), [5] Da Cunha et al. (2017), [6] ECDC (2020), [7] Coburn et al. (2009), [8] Poletto et al. (2014), [9] Khan et al. (2015), [10] Towers et al. (2016), [11] Sanche et al. (2020).

Year	Outbreak	Fatality rate	R_0 (Transmission rate)
2003	SARS[1]	11%	3.0[1]
2009	Swine Flu[2]	1%	1.6[7]
2012	MERS[3]	35%	0.5[8]
2014	Ebola Virus[4]	50%	1.7[9]
2016	Zika Virus[5]	8%	3.8[10]
2020	COVID-19[6]	3.5%	5.7[11]

Table 2
S&P 500 Index price movements during major viral outbreaks. Peak-to-trough losses were almost two-fold during COVID-19 when compared to SARS. Notably, taking just 23 trading days versus 38.
Source: [12] Citi Market Insights (2020); [13] Bloomberg

Year	Outbreak	Peak-to-Trough returns	Trading days
2003	SARS[12]	−17.3%	38
2009	Swine Flu[13]	−5.8%	9
2012	MERS[12]	−7.3%	43
2014	Ebola Virus[12]	−5.8%	23
2016	Zika Virus[12]	−12.9%	66
2020	COVID-19[13]	−33.7%	23

Among the methodologies used, it appears that panel regression analysis and event-study regressions are currently the favoured methods. Panel data analysis is widely used in both epidemiology and econometrics, making it an appropriate methodology for the current COVID-19 pandemic. Using panel data spanning January to April, Ashraf (2020) found that stock markets reacted strongly to growth in confirmed cases, but not to confirmed deaths. On the other hand, Ali et al. (2020) conducted bivariate regressions and found returns to be negatively and significantly related to COVID-19 deaths.

Examining Chinese stock markets, Al-Awadhi et al. (2020) used a panel regression analysis and found that both the daily growth in confirmed cases and fatalities resulted in statistically significant negative returns on stock markets. Empirical results from Zhang et al. (2020) indicated that COVID-19 directly impacted volatility on stock markets worldwide. Additionally, Baker et al. (2020) used textual analysis in their assessment of the stock market impact of COVID-19. Analysing newspaper articles published with relevant keywords, the authors' findings suggest that no infectious disease outbreak as far back as 1900 had affected stock markets to the same extent as COVID-19. They found that news related to COVID-19 (both positive and negative) was the dominant driver of large daily U.S. stock market movements between late February 2020 and April 2020.

This study adds to the current literature in several ways. Firstly, we differ from the aforementioned research (Al-Awadhi et al., 2020; Ashraf, 2020) as we not only test the relationship between cases and returns, but also measure the significance of COVID-19 while controlling for several conventional market drivers. These drivers range from trading volumes to volatility indicators to safe-haven assets to fixed-income market indicators. In contrast, Ashraf (2020) includes variables that control for democratic accountability, investment freedom and GDP.

Secondly, this study adds to the literature set by encompassing the entire 'first wave' of COVID-19 transmission in each respective territory (Fig. 1). Capturing data over the December 2019 to June 2020 period thus facilitates a robust analysis into the reaction of stock markets as growth in the virus began, surged, peaked, and eventually slowed. Thirdly, another approach to COVID-19 studies has been the utilisation of event study analysis to assess the market's immediate reaction (Liu et al., 2020). However, this methodology assumes the market's initial reaction to events reflects their true economic impact in an unbiased manner (Oler et al., 2008). To capture the full extent of the pandemic's first wave, we make use of a linear regression model rather than an event study analysis.

Recent literature has described the COVID-19 pandemic as a stock market black swan event (Morales and Andreosso-O'callaghan, 2020). Caution must be heeded if treating the COVID-19 pandemic as a black swan event as there may be a subsequent failure to adequately prepare for future pandemics, or another event that results in global societal upheaval. The rarity and exceptional nature of 'black swan' events can be used as an argument to reject the likelihood and severity of future reoccurrences. Thus, the 'black swan' label may detract focus from the necessary risk analysis and predictive modelling that must be carried out following such events. Goodell (2020) explored agendas for future COVID-19 research, arguing that it is likely that there will be a substantial reaction from financial markets in the event of another sudden and significant viral outbreak. Travel restrictions, social distancing measures and temporary shutdowns of commerce are expected to be the standard course of action when a novel pathogen inevitably emerges once more (Bearman et al., 2020; Khanna et al., 2020). Therefore, it is imperative that the financial impact of pandemics is further investigated.

The true economic impact of COVID-19 will remain unseen for some time. At the time of writing, countries are beginning to ease lockdown restrictions as people slowly return to work. With this, countries are only now beginning to take stock of the economic, social, and political costs of both the pandemic and the subsequent economic shutdown. Stringent regulations in the wake of the 2007–2009 global financial crisis have left banks more capitalised, potentially allowing for a quick economic recovery. Nevertheless, a report by the Bank of England (2020b) estimated a GDP contraction of 25% in Q2 2020 with an estimated contraction of 14% by year-end. Similar estimates of 20%–30% were announced by the Chairman of the Federal Reserve Jerome Powell (2020). This coincided with predictions from the IMF (2020a) that the COVID-19 recession will likely be the worst since the Great Depression.

However, before the long-term economic impacts can be quantified, an analysis into the short-term stock market implications is warranted. Global stock market losses of $16 trillion were observed in less than a month as the pandemic took hold and as fears rose of a worldwide recession (Gandel, 2020). As such, an analysis into the determinants of global stock market indices as COVID-19 grew will provide valuable insights into the evolving market dynamics and price drivers during times of crisis and uncertainty. The study proceeds as follows. Section 2 describes the data sources and parameter selections for the regression models. Section 3 describes the empirical methodology used in the investigation. Section 4 presents the results and discusses the implications of these findings in the context of contemporary market indicators and prior viral outbreaks. Section 5 concludes the analysis.

2. Data

2.1. Data collection

Daily data of cumulative case numbers and fatalities from COVID-19 was sourced from the European Centre for Disease Prevention and Control (ECDC, 2020). The data spanned the date range of 31st December 2019–10th June 2020, corresponding

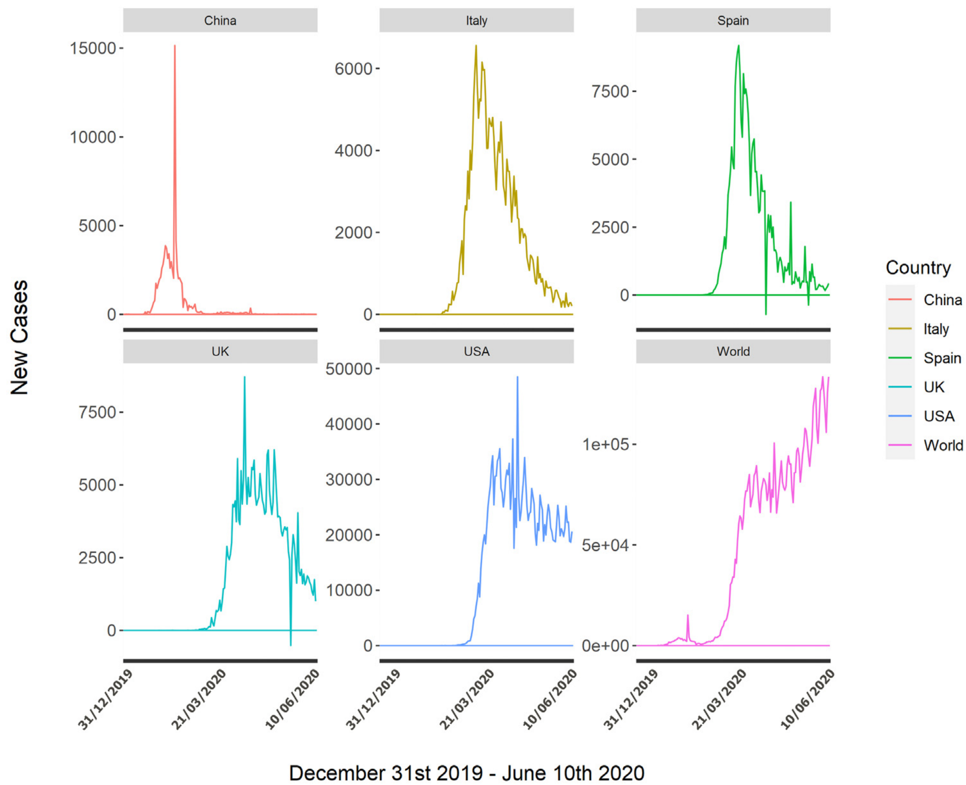

Fig. 1. The daily number of new COVID-19 cases in each territory from December 31st 2019 to June 10th 2020. An exponential rise is observed for each country to varying extents. The entire 'first wave', often referred to in epidemiology appears to have been captured for China, Italy, Spain, and the U.K. For global data and data for the U.S.A., this curve appears to have been captured to a lesser extent.

to $n = 117$ trading days. The data was then transformed to provide eight daily indicators of COVID-19 growth that may have influenced stock market indices, outlined below:

Cases:	**Deaths:**
Total number of cases	Total number of deaths
Growth in total number of cases	Growth in total number of deaths
Number of new cases	Number of new deaths
Growth in number of new cases	Growth in number of new deaths

Growth rates are represented as a daily arithmetic growth rate, in line with the reporting methods used by several media outlets throughout the pandemic (Bruce and James, 2020; Cullen, 2020; Harrison, 2020). Preliminary testing of the eight COVID-19 indicators against index prices revealed 'Total Cases' as the highest correlated variable when averaged across the territories (Table 3). The remaining seven growth indicators are disregarded, since they are all either highly correlated with Total Cases, or uncorrelated with index prices.

The territories chosen for this analysis are China, Italy, Spain, the United Kingdom, the United States, and a measure for the global impact of COVID-19. The equity indices associated with these territories, as well as the justification for their inclusion, are outlined in Table 4. The prices associated with each equity index were obtained through Bloomberg. To align calendar days with trading days, COVID-19 case numbers reported on weekends were added to the next trading day's figures. Essentially, this is to tap into investor sentimentality and the reaction of stock market prices following an accumulation of news over the weekend period. As such, COVID-19 data is lagged one-day behind index prices. Fig. 2 illustrates the daily price of each regional equity index over the period 31st December 2019 to 10th June 2020, highlighting the sharp initial reaction of global markets to the onset of the pandemic. Examining both Fig. 1 and Fig. 2 concurrently, it can be seen that equity markets responded quickly and sharply to the initial growth of the virus, before rebounding and ultimately trending in the same direction as growth in the virus.

Table 3
Correlation analysis of the eight COVID-19 growth variables against equity index prices in each region examined. Although different indicators appear more strongly correlated in different regions, Total cases emerges as the highest correlated variable, when averaged across the territories.

COVID-19 growth indicator	Index price correlation					
	China	Italy	Spain	UK	USA	World
Total cases	−0.61	−0.66	−0.70	−0.39	−0.22	−0.16
Total deaths	−0.56	−0.61	0.65	−0.39	−0.19	−0.17
New deaths	0.04	−0.57	−0.42	−0.48	−0.37	−0.42
New cases	0.06	−0.55	−0.51	−0.47	−0.41	−0.32
Total death growth	0.27	−0.03	−0.18	−0.37	0.34	0.21
Total case growth	0.23	0.10	0.05	−0.20	−0.11	0.20
New death growth	0.02	−0.14	−0.19	−0.24	−0.19	0.10
New case growth	0.11	−0.14	−0.05	−0.14	−0.02	0.11

The selection of explanatory and control variables detailed in Section 2.2 are obtained from various sources. Trading Volume, Volatility Indices, Gold prices, and Brent Crude Oil prices were sourced from a Bloomberg Terminal. The LIBOR-OIS Spread and TED Spread (or local alternatives) were sourced from the Federal Reserve Economic Database (FRED), European Central Bank (ECB), Bank of England (BOE) and China Central Depository & Clearing (CCDC), respectively.

Table 5 presents summary statistics detailing the growth of COVID-19 in all six regions included in this analysis. It can be seen that the maximum daily index return during the period was 11.37% (*USA — Dow Jones Index*) on the 29th February, 2020

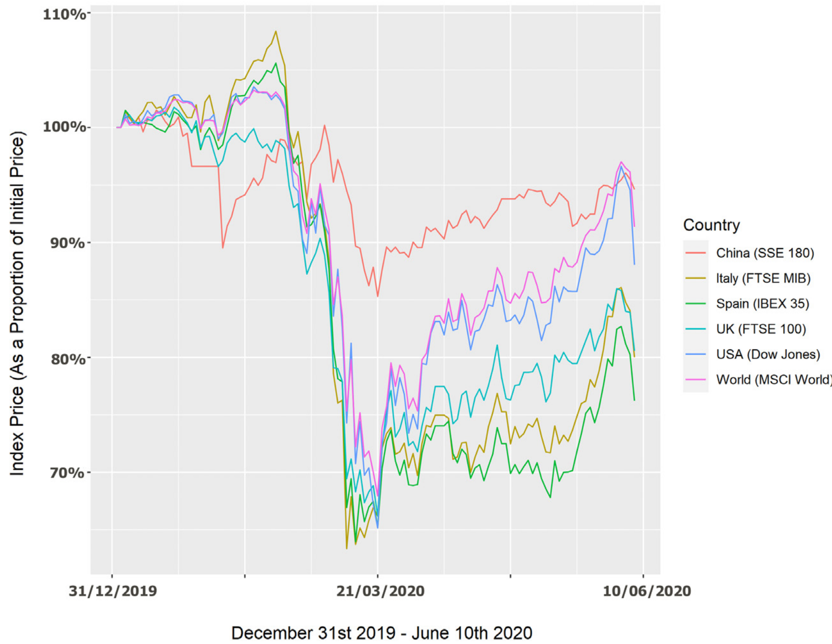

Fig. 2. The daily price of equity indices from December 31st 2019 to June 10th 2020. 100% = each of the respective market's equity index price as of close, December 31st 2019. When compared with Fig. 1, it is clear that the initial growth in confirmed cases of COVID-19 was met with a concurrent sharp fall in each of the equity indices. However, prices began recovering long before COVID-19 growth rates had peaked.

Table 4
Territories and equity indices chosen for analysis in this study. Beginning with China as the global origin of the virus, the remaining four countries were chosen as they chronologically established themselves as global epicentres of the virus over the course of the pandemic period.

Country		Equity index	Justification for selection
	China	SSE 180	Global origin of virus
	Italy	FTSE MIB	First European epicentre
	Spain	IBEX 35	Second European epicentre
	UK	FTSE 100	Final European Epicentre
	USA	DJIA	Final global epicentre
	World	MSCI World Index	World

while the minimum daily return was observed as −16.92% (*Italy — FTSE MIB*) on the 21st February, 2020. In terms of COVID-19 growth, the highest 1-day rise in total cases was 173% *(Italy — 22nd February)* and the highest 1-day growth in total fatalities was 460% (Spain – *10th March*). It should be noted that large minimum and maximum figures are biased toward the beginning of the growth period. These figures signified large increases in scale while absolute numbers remained relatively small. Of the five global epicentres of the virus, Spain saw the largest mean daily increase in both cases and fatalities (9.47% and 9.98%), while China saw the lowest (4.91% and 5.15%).

2.2. Variable selection

The objective of this analysis is to determine the impact that COVID-19 growth had on stock index performance while controlling for a number of market factors. Given the short and sharp growth of COVID-19, a limited number of market factors were suitable for inclusion as control variables in our study. A total of six additional variables per region (in addition to COVID-19 growth) are used to explain index prices. In the next section, we provide details of the market factors, justify their suitability for the study, and highlight their use in prior literature. The specific rates and indices used are provided in Tables 8–11 (Appendix).

Trading Volume: MEASURE OF: MARKET ACTIVITY

As a direct indicator of market activity, trading volumes are included to assess whether their fluctuations play a role in explaining index prices in subsequent trading days. Trading volume is typically used as a proxy for a shift in investor demand – Campbell et al. (1993) highlight an implicit positive correlation between price and volume, warranting its inclusion.

Volatility Index: MEASURE OF: INVESTOR SENTIMENT | VOLATILITY

Volatility indices represent the forward expectation of volatility in financial markets. The index is typically derived from the price inputs of major index options. Although forward-looking, it is suitable as a control variable since it is an ex-post measure of market activity, is considered a proxy for the current sentiment of investors, and has been shown to be significantly linked with market returns (Poshakwale et al., 2019).

LIBOR-OIS Spread: MEASURE OF: COUNTERPARTY CREDIT RISK | LIQUIDITY RISK

An overnight indexed swap (OIS) rate is a forward-looking view on the average target rate for a central facility, for a set period of time. In the United States, this is often set to be the Effective Federal Funds Rate (EFFR), an indicator of unsecured borrowing rates between banking institutions to satisfy liquidity requirements. The probability of counterparty risks occurring overnight between these institutions is low. Therefore, the OIS rate is considered a near-riskless rate since credit risk will not be a major factor in its determination (Sengupta and Tam, 2008). The indexed rate varies per region. Calculated in largely the same way as the EFFR, the EONIA, SONIA and SHIBOR Overnight Index are used in the Eurozone, U.K., and China, respectively.

In contrast, LIBOR is the rate at which banking institutions will borrow from each other on an unsecured basis for a set period of time to fund daily operations. While LIBOR USD/GBP are used in the U.S.A. and the U.K., the EURIBOR and SHIBOR are used in

Table 5
Summary statistics for both the stock market equity indices and the COVID-19 data used in this analysis. The daily log-return was chosen for consistency across indices and to maintain symmetry in price changes. In relation to the COVID-19 related growth rates, the simple arithmetic growth rate was used, in line with reporting methods used by several media outlets throughout the pandemic. All COVID-19 growth rates represent the 1-day growth rate in the cumulative number of cases or fatalities.

Country		Daily growth:	Mean	Std. Dev.	Minimum	Maximum
China		Index returns	−0.05%	1.40%	−7.63%	3.19%
	$(n = 117)$	Total cases	4.91%	12.77%	<0.01%	99.33%
		Total fatalities	5.15%	13.67%	0.02%	104.15%
Italy		Index returns	−0.15%	2.86%	−16.92%	8.93%
	$(n = 117)$	Total cases	8.70%	30.35%	0.08%	173.46%
		Total fatalities	8.47%	24.72%	0.15%	200%
Spain		Index returns	−0.20%	2.65%	−14.06%	7.82%
	$(n = 117)$	Total cases	9.47%	17.65%	−0.37%	109.86%
		Total fatalities	9.98%	41.63%	−6.67%	460%
U.K.		Index returns	−0.16%	2.35%	−10.87%	9.05%
	$(n = 117)$	Total cases	9.00%	12.30%	−0.211%	69.31%
		Total fatalities	8.66%	22.46%	0.14%	180%
U.S.A.		Index returns	−0.06%	3.17%	−12.93%	11.37%
	$(n = 117)$	Total cases	8.85%	14.36%	0.95%	91.63%
		Total fatalities	9.16%	21.42%	0.45%	200%
World		Index returns	−0.08%	2.52%	−10.44%	8.41%
	$(n = 117)$	Total cases	8.85%	17.04%	0.67%	163.86%
		Total fatalities	9.94%	20.76%	0.24%	183.33%

the Eurozone and China, respectively. Unlike the OIS rate, LIBOR is affected by credit and liquidity risk. During times of economic stress, LIBOR and OIS rates tend to diverge (Brunnermeier, 2009; Sarkar, 2009). The difference, or spread, between LIBOR and OIS rates has previously been referred as "a barometer for fears of insolvency in the banking sector" (Thornton, 2009). A widening of the LIBOR-OIS spread indicates a deterioration of credit conditions, which may significantly affect market returns (Florackis et al., 2014). In our analysis, we use the LIBOR-OIS spread as a proxy for how the level of aggregate liquidity and credit risk may have changed in the interbank market with the onset of COVID-19.

TED Spread: MEASURE OF: COUNTERPARTY CREDIT RISK | LIQUIDITY RISK

The TED Spread is the difference between the yield on a three-month U.S. Treasury Bill and the three-month LIBOR USD Rate. This difference represents the risk premium charged on top-rated interbank loans versus risk-free loans, and so is often seen as an indicator of the perceived credit risk in an economy (Boudt et al., 2017). Therefore, like the LIBOR-OIS spread, it can also be used as an indicator of overall economic health. As such, it is a suitable indicator for credit risk and overall economic risk during the COVID-19 pandemic. Outside of the US TED Spread, the yields on generic 3-month government bonds and their associated interbank rates were used in this study.

Gold: MEASURE OF: SAFE-HAVEN ASSET DEMAND

Gold has been described as a safe-haven asset during turbulent market conditions (Baur and Lucey, 2010), with the safe-haven effect lasting for up to 15 trading days after an extreme shock. As such, it is a suitable control variable for the recent shock of COVID-19 on financial markets and the extended period of economic uncertainty that transpired. If gold is a significant independent variable, it may indicate that stock market prices were depressed as a result of investors flocking out of equity investments and into safe-haven assets.

Brent Crude Oil: MEASURE OF: INFLATION | GLOBAL OIL PRICE TENSIONS

Oil shares an inverse relationship with stock markets, as with gold (Sakaki, 2019). As oil prices rise, the cost of energy increases, resulting in systemic inflation in the economy as the overall cost of doing business rises. In light of the highly volatile global oil markets during March 2020 (Masson and Winter, 2020), the price of oil is a relevant and potentially significant factor in recent stock market prices.

Guided by relevant financial literature, the above variables have been chosen to represent several of the dynamics that typically underlie financial markets. By including measures of investor sentiment, economic health, counterparty credit risk, liquidity risk, safe-haven asset demand and the price of oil, this analysis seeks to identify which (if any) of the above were significant in explaining index prices during the COVID-19 pandemic.

3. Methodology

3.1. Stepwise multiple regression analysis

It is both evident and intuitive that COVID-19 is linked to the recent downturn in financial markets. We showcase this through the use of linear regression analyses. The objective of a linear regression analysis is to find an optimally weighted average of predictor variables to explain an outcome variable. The objective of this study is to highlight changes in equity index prices are significantly explained by the evolution of COVID-19 cases. Furthermore, we explore whether a number of conventional market factors can provide a 'better' explanation for the change in the equity index prices, rather than COVID-19 alone. Therefore, a combination of control variables that render the 'COVID-19 cases' variable non-significant can be justified as the combination of market factors that influenced equity index price dynamics during COVID-19. Each model takes the form:

$$Y_i = \beta_0 + \beta_1 X_{i1} + \cdots + \beta_k X_{ik} + \varepsilon_i \quad (1)$$

where β_0 describes the intercept and each subsequent β_k describes the optimal explanatory weight associated with each of the variables X_{ik}. A model is created for each of the territories outlined in Table 4 (ranging from $i = 1 \ldots 6$), using each of the variables outlined in Section 2.2 (ranging from $k = 1 \ldots 7$). With seven potentially-significant, there are 2^7 potential model combinations that could be used to explain index prices in each territory. Therefore, we use forward selection to find the optimal fit for each model, as measured by the Akaike Information Criterion (AIC) (Eq. (2)) and the Bayesian Information Criterion (BIC) (Eq. (3)). The forward selection method is chosen in order to avoid interaction or suppression effects between individual variables. Model fit is computed as:

$$AIC = n\log(SSE) - n\log(n) + 2(k+1) \quad (2)$$

$$BIC = n\log(SSE) - n\log(n) + \log(n)(k+1) \quad (3)$$

where n describes the number of observations, SSE describes the sum of the squared errors, and k describes the number of predictors in the model.

The selection method requires consideration given the balance needed between optimal fit and model parsimony. The AIC measure penalises for excess variables in the model when assessing goodness-of-fit; it removes these excess variables in order to prevent overfitting. The BIC performs a similar function and favours a more parsimonious model as n increases beyond 100 observations (since $\log(100) = 2$). The objective of the analysis is to find the optimal model for explaining index returns by successively removing non-significant variables. The final model fit may therefore exclude the influence of 'COVID-19 Growth' as a significant predictor, while the remaining variables showcase the market factors that determined index price fluctuations during the first wave of the COVID-19 pandemic. AIC has been argued to be better suited for prediction purposes since it favours a greater closeness of fit, while BIC is better suited for the purposes of explanation (Shmueli, 2010). Therefore, we base our model fit selection method on the BIC value. In any case, given that the number of trading days in the analysis is 117 (Table 5), the differences in AIC and BIC scores will be minimal. The analysis is performed using the open-source programming language, R.

4. Results & discussion

4.1. Effect of COVID-19 on equity markets

To confirm whether COVID-19 can explain fluctuations in the prices of international equity indices, we carry out a set of initial cross-sectional linear regression analyses. These analyses include the total number of confirmed COVID-19 cases as an independent variable, and each territory's index price as a dependent variable. The results are outlined in Table 6. The models are presented in chronological order as the virus established global epicentres, moving from China (1), to Italy (2), to Spain (3), to the United Kingdom (4) and finally to the United States (5). The final trading day we include in our analyses (10th June 2020) coincided with the United States being established as the global epicentre of COVID-19. Additionally, a model incorporating COVID-19's influence on the MSCI World Index (6) is included.

The results in Table 6 confirm that COVID-19 was significantly associated with changes in index prices across all regions. The strongest effects are found in China, Italy, Spain, and the UK. In these regions, total COVID-19 cases significantly explain fluctuations in index prices with 99% level of confidence. Smaller effects are found for the United States (95% level of confidence) and for the World Index (90% level of confidence), but COVID-19 remains a significant explanatory factor regardless.

Following the results of Table 6, we include conventional market factors that could serve as control variables – i.e. market factors that could explain the variance in index prices that are otherwise explained by COVID-19. Table 7 presents the results of the six stepwise linear regression models. The models are once again presented in chronological order as the virus established global epicentres, moving from China (1), to Italy (2), to Spain (3), to the United Kingdom (4) and finally to the United States (5). The MSCI World Index (6) is again included. All six models achieved significant model fit, with the variance explained in all markets except for China being greater than 90% (Table 7). These fit statistics represent significant improvements over the models in Table 6, which only included total COVID-19 cases. Implied volatility, total COVID-19 cases, Brent crude oil prices, and the LIBOR-OIS spread were most significantly associated with equity index price changes.

4.2. Parameter effects

4.2.1. COVID-19

Overall, the findings suggest a significant and negative impact of COVID-19 on major stock market indices. Indices in Spain, Italy, the U.K., and the U.S.A. were found to be negatively and significantly related to the total number of COVID-19 cases. This occurred despite controlling for other market drivers. These findings are in line with those currently available from the ongoing pandemic. Ashraf (2020), Al-Awadhi et al. (2020), and Sansa (2020) all report similar findings, with COVID-19 cases negatively and significantly associated with stock markets in each study.

However, COVID-19 cases did not significantly influence the sharp fall and subsequent rise of the Chinese SSE 180 index. Instead, fluctuations in market prices were explained by trading volumes, the price of Brent crude oil, implied market volatility, and the TED spread. Similarly, COVID-19 cases did not significantly influence the MSCI World index. This index represents large and mid-cap companies in 23 developed markets. Although global indices may provide the benefits of international diversification, the findings suggest that in times of serious crisis and economic disruption, this may not be the case. Instead, changes in this index can be explained by the level of volatility implied by the market, the price of Brent crude oil, and the LIBOR-OIS spread (acting as a barometer for risk-linked market liquidity).

4.2.2. Implied volatility

Implied volatility remained a significant indicator across all indices, indicating that this may have been the most influential variable in explaining price fluctuations. This is an unsurprising result, as measures of implied volatility have historically seen an inverse relationship with stock prices (Rosillo et al., 2014).

4.2.3. Brent crude oil

The price of Brent crude oil remained positively and statistically significant for China, the UK, the US, and the MSCI World index. Amid high tensions in the global oil market, it was unsurprising that the price of Brent crude oil remained significant in four of the six regression models. However, the conventional inverse relationship between oil and stock prices is not present in the findings. Each coefficient is positive, indicating that increases or decreases in the price of oil is associated with the same directional movement in index prices. In the case of COVID-19, this directional relationship makes sense. An unprecedented erosion of oil demand as a result of pandemic-induced economic shutdowns initially drove oil prices down, signalling a diminished level of total economic activity to financial markets. Alongside a depressed demand, a breakdown in negotiations between OPEC, Russia and Saudi Arabia resulted in both Saudi Arabia and Russia announcing unprecedented plans to increase oil production. As demand continued to diminish due to COVID-19, an additional surplus in supply led to an oil price war between Russia and Saudi Arabia with Brent decreasing as much as 26% in early March alone (Egan, 2020).

Under current COVID-19 conditions, the price of oil may instead act as a gauge of economic activity and of global political tensions, thus explaining the positive association observed with index prices. As the price of oil rose from May onwards, so too did global index prices. Kilian and Park (2009) address this relationship. They state that the resilience of stock markets in the presence of increasing oil prices can be explained by strong global

Table 6
Models (1) to (6) represent the significance of COVID-19 (Total cases) without the control variables included. R^2 values for the first three global epicentres of the pandemic (China, Italy, and Spain) are notably higher than the U.K., the U.S.A., and the World indices. This may be as result of the spatiotemporal nature of COVID-19 growth and the initial market panic observed worldwide, irrespective of the actual location of the virus.

Dependent variable: Equity Index Price						
	SSE 180 CHINA (1)	**FTSE MIB** ITALY (2)	**IBEX 35** SPAIN (3)	**FTSE 100** UK (4)	**DJIA** USA (5)	**MSCI World** WORLD (6)
Independent Variable						
Total cases	−0.006***	−0.022***	−0.009***	−0.003***	−0.001**	−0.00002*
(Standard errors)	(0.001)	(0.002)	(0.001)	(0.001)	(<0.001)	(0.00001)
Constant	8750.56***	22,060.59***	8851.43***	6696.81***	26,072.29***	2166.21***
(Standard errors)	(50.95)	(323.35)	(122.27)	(89.40)	(331.39)	(26.18)
Observations	117	117	117	117	117	117
R^2	0.37	0.43	0.49	0.15	0.05	0.03
Adjusted R^2	**0.36**	**0.42**	**0.49**	**0.15**	**0.04**	**0.02**
Res.Std.Error (df = 115)	262.54	2531.83	967.20	769.19	2849.85	223.26
F Statistic (df = 1; 115)	67.43***	86.20***	111.75***	20.84***	5.71**	3.17*
AIC	1639.49	2169.80	1944.62	1891.02	2197.49	1601.56
BIC	1647.78	2178.09	1952.91	1899.31	2205.78	1609.85

Note: *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

Table 7
Models (1) to (6) represent the final stepwise regression model for each region under the Bayesian Information Criterion. The price associated with each market (Equity Index Price) is listed from left-to right, beginning with the Chinese SSE 180 index. A number without parentheses represents a regression coefficient while a number inside parentheses represents a standard error.

Dependent variable: Equity Index Price						
	SSE 180 CHINA (1)	**FTSE MIB** ITALY (2)	**IBEX 35** SPAIN (3)	**FTSE 100** UK (4)	**DJIA** USA (5)	**MSCI World** WORLD (6)
Independent variable						
Imp. Volatility	−16.01***	−129.22***	−49.57***	−27.65***	−121.52***	−7.66***
(Standard errors)	(2.24)	(4.26)	(1.68)	(1.73)	(12.32)	(0.57)
Total cases		−0.011***	−0.006***	−0.001***	−0.001**	
(Standard errors)		(<0.001)	(0.001)	(<0.001)	(<0.001)	
Brent	9.73***			20.15***	68.05***	4.95***
(Standard errors)	(1.94)			(2.48)	(15.22)	(0.58)
LIBOR-OIS		−9556.77***	−2953.01***			−68.53***
(Standard errors)		(1896.52)	(772.99)			(22.72)
Gold				−1.47***	6.35***	
(Standard errors)				(0.39)	(1.99)	
TED Spread	−187.76***					
(Standard errors)	(61.70)					
Volume	2.24e-8***					
(Standard errors)	($7.53e^{-9}$)					
Constant	8394.71***	26,399.42***	10,492.74***	8939.50***	16,521.74***	2207.59***
(Standard errors)	(114.00)	(173.61)	(67.64)	(720.99)	(3583.43)	(38.77)
Observations	117	117	117	117	117	117
R^2	0.78	0.95	0.95	0.97	0.92	0.93
Adjusted R^2	**0.77**	**0.95**	**0.95**	**0.97**	**0.91**	**0.93**
Res.Std.Error	156.44 (df = 112)	754.01 (df = 113)	292.49 (df = 113)	155.11 (df = 112)	853.13 (df = 112)	59.42 (df = 113)
F Statistic	100.12*** (df = 4;112)	718.50*** (df = 3;113)	788.79*** (df = 3;113)	807.10*** (df = 4;112)	308.73*** (df = 4;112)	518.42*** (df = 3;113)
AIC	1521.55	1888.31	1666.72	1519.25	1918.17	1293.76
BIC	1538.12	1902.12	1680.53	1535.83	1934.74	1307.57

Note: $p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

demand for industrial commodities, which can more widely be representative of increasing economic activity. As such, any indication of increasing economic activity during COVID-19 was a positive indicator to financial markets.

4.2.4. LIBOR-OIS spread

The LIBOR-OIS Spread emerged as statistically significant for Italy, Spain, in addition to the World index. Before the pandemic, the IMF (2020b) warned that 40% of corporate debt in major economies could be at risk in a global downturn. As COVID-19 took hold and economies shutdown, corporate liquidity effectively dried up, and the LIBOR-OIS spread rose to the highest level seen since the global financial crisis of 2007–2009. Companies began drawing on short-term credit lines in order to shore up balance sheets, with over $120 trillion drawn by European and American companies in less than one month (Platt et al., 2020). As pandemic-induced shutdowns took hold, consumer demand diminished, corporations drew increasingly on short-term credit lines, and the demand for liquid assets increased significantly (Bank of England, 2020a).

The significance of the LIBOR-OIS spread for Spain and Italy, but not for the United States, is a compelling finding from this study. One possible explanation is rooted in the response of central institutions to the pandemic. The Federal Reserve notably responded swiftly, reducing the Federal Funds Rate by 50 basis points (0.5%) in an attempt to promote investment and a greater level of economic activity. In the same announcement, daily overnight secured loans up to at least $175 billion were provided, alleviating money market pressures and ensuring an ample supply of reserves (Federal Reserve, 2020). This injection of confidence to the market importantly came just before tensions in the global oil markets emerged.

On the other hand, the ECB lagged briefly in their response (Collins and Gagnon, 2020), possibly due to the asynchronicity of the member states. The difference in policy response may explain why the LIBOR-OIS remained significant in European markets, but not American. These findings are similar to those of Ramelli and Wagner (2020), who found that corporate debt and cash holdings emerged as important value drivers as the virus spread to Europe and the United States.

4.2.5. Gold

Gold did not act as a safe-haven or a 'flight-to-safety' asset (Akyildirim et al., 2020) during the downturn for the majority of territories, with a significant result only observed for the UK and US indices. Our findings are consistent with the findings of Corbet et al. (2020). As in their analysis, we find no significant relationship between Gold and Chinese stock markets in the current pandemic. It can be suggested that in times of serious financial and economic disruption, gold fails to act as a safe-haven and may instead act as an amplifier of financial contagion.

4.2.6. TED spread & trading volume

The TED spread and Trading Volume indicators were only significant in influencing the Chinese SSE 180 index. This result may likely be due to the similarity between the LIBOR-OIS spread and the TED spread. We find that the U.S. TED spread and the LIBOR-OIS shared a correlation of over 98% over the period analysed. Conversely, China's equivalent measure of the TED Spread (3M SHIBOR minus 3M ChinaBond Yield) shared a correlation of 64%, potentially explaining its inclusion in model (1) but not in any other model. The effects of the trading volume, however, can be reasoned in conjunction with the spread of the virus. While the COVID-19 crisis appeared on paper to have effectively abated in China by the beginning of March, the other regions examined were just beginning to experience the pandemic. The swiftness with which controls were implemented in China could possibly have tamed the effects of the virus on markets much quicker, rendering it a non-significant parameter.

4.3. Viral outbreaks on international markets: Past and present

The current literature on viral outbreaks is limited to an extent, as the scale of the current COVID-19 pandemic has been unseen in over a century. As such, the implications of COVID-19 may be guided by examining prior viral outbreaks. SARS was consistently referred to as a template for how COVID-19 may impact the economy and stock markets (Avalos and Zakrajšek, 2020; Decambre, 2020). However, despite a peak-to-trough stock price movement of 17.3% on the S&P 500, Nippani and Washer (2004) declared SARS a 'non-event' for affected countries' stock markets overall. Similarly, Loh (2006) found that the negative repercussions of SARS on airline stocks surfaced in the form of increased volatilities rather than lower mean returns. Conversely, Chen et al. (2007) analysed Taiwanese hotel stock prices in the aftermath of SARS, and found that stock prices showed significant and abnormal negative returns on and after the day of the SARS outbreak. Despite a lack of consensus on the direct stock market implications, the overall financial cost of the SARS outbreak was unequivocally significant, with Delisle (2003) finding the losses to exceed that of the Asian financial crisis, estimating losses of $3 trillion in GDP and $2 trillion in financial market equity.

Looking at the implications of the Spanish Flu of 1918–1919, Garrett (2008) found that cities with higher rates of influenza mortalities experienced higher real wage growth and higher income growth in the decade proceeding the pandemic. These findings echo those of Brainerd and Siegler (2003), who found the Spanish Flu led to an increase in U.S. economic growth in the 1920s. However, war-time economics and post-war optimism are heavily confounding factors in any analysis of the stock market during the Spanish Flu, so it may not provide a clear comparison for the present COVID-19 pandemic. Ichev and Marinč (2018) and Del Giudice and Paltrinieri (2017) investigated the impact of the Ebola virus outbreak on U.S. and African financial markets, respectively. Ichev and Marinč (2018) observed a negative impact on U.S. listed stocks with business operations exposed to West Africa. It is clear there is a lack of consensus regarding the direct impact of viral outbreaks on stock markets. Despite noteworthy economic and financial losses, evidence of a sustained and significant negative impact on stock markets is inconclusive from prior outbreaks.

Nevertheless, this study highlights the market factors that are key in explaining index prices beyond COVID-19 growth. This analysis builds on the current COVID-19 related research by encompassing the first wave of the COVID-19 pandemic, from 31st December 2019 to 10th June 2020. We find, with over 90% of the variance explained in price fluctuations, that COVID-19 significantly influenced equity markets in Spain, Italy, the United Kingdom, and the United States. This result persisted even in the presence of control variables. However, COVID-19 growth did not significantly affect the Chinese SSE 180 index, nor did it affect the MSCI World index. Instead, changes in these respective market prices were explained by implied market volatility and the price of Brent crude oil. The SSE 180 index was additionally influenced by trading volumes and the TED spread, while the MSCI World index was additionally influenced by the LIBOR-OIS spread.

4.4. Implications of results

Despite the rarity of pandemics, it is a distinct possibility that we will encounter further 'adversarial events' that can significantly disrupt societies and impact the global economy. Therefore, the current pandemic gives us a unique opportunity to identify insights that can inform preparations for future adversarial events. Firstly, early efforts to taper market panic could have prevented large price fluctuations. Our results indicate that investor sentiment impacted market prices before any observable financial damage was incurred. The association between the early negative shock to equity prices and investor sentiment is consistent with the belief that variations in the values of stock markets are largely due to changes in expected returns, rather than revisions in expected financial growth rates (Campbell and Shiller, 1988; Gormsen and Koijen, 2020).

Secondly, the results suggest that early interventions to limit the spread of COVID-19 can be effective in limiting the impact on equity markets. China curtailed the spread of the virus by early March (Zhang et al., 2020), coinciding with the time the virus was declared a pandemic by the World Health Organisation (2020a). In contrast, the remaining territories (Italy, Spain, UK, US) did not immediately implement curtailing measures, exacerbating the spread of the virus and its effect on equity markets. Based on our findings, China's early interventions may have rendered the effect of COVID-19 a non-significant factor in explaining changes in index prices. On the other hand, research emerging from He et al. (2020) may indicate under-reported COVID-19 cases within official Chinese data. Using epidemiological growth models, cremation estimates and Chinese official data, the study finds a reasonable death-toll estimate of more than ten times the magnitude of the official death toll recorded. Thus, it is also possible that a potentially spurious dataset is currently available for the analysis of COVID-19 in some territories. Future work should therefore consider all available and reasonable data sources, in order to gain a thorough understanding of the impact of the COVID-19 pandemic.

Thirdly, our findings for the changes in MSCI World Index prices lends evidence to the importance of the timing of COVID-19 growth, as it relates to financial markets. The global epicentre of COVID-19 shifted on a number of occasions. Beginning in China, it spread to Europe, and then to the United States. We find that price movements in all localised markets (apart from China) are largely explained by the growth in total COVID-19 cases. On the other hand, the growth in COVID-19 cases did not significantly explain the extensive fluctuations in the MSCI World Index. Since the aforementioned regions were not all significantly affected by COVID-19 at once, we theorise that a strong association between the MSCI World index and COVID-19 did not manifest due to the shifting spatiotemporal nature of COVID-19 growth.

5. Conclusion

This study examined the response of equity index prices to the ongoing COVID-19 pandemic. We hypothesise that the daily total count of confirmed COVID-19 cases served as a significant factor in influencing market prices. Our analysis builds on the current literature in two ways. Firstly, we investigate whether growth in COVID-19 played a significant role in international market prices (China, Italy, Spain, UK, US, World). Our findings confirm that equity index prices suffered a significant negative shock in conjunction with the growth of the pandemic. Secondly, we investigate whether this relationship persisted while controlling for a number of conventional market drivers. Specifically, we investigate whether the growth in COVID-19 cases was significant at explaining regional index prices, while controlling for investor sentiment, counterparty credit risk, liquidity risk, safe-haven asset demand and the price of oil.

The current pandemic provides us with a unique opportunity to identify the effect that pandemics have on financial markets. The results suggest that the implied volatility of the respective markets, often used as a proxy for investor sentiment, played a greater role in explaining market prices than COVID-19 growth. All major index prices included in this analysis were largely explained by this factor. Our findings indicate that investors began to act before any realised financial damage was observed. We additionally find that changes in the Chinese SSE 180 index and the MSCI World index prices were not significantly explained by COVID-19 growth. Instead, these indices were largely influenced by conventional market drivers linked to economic growth. We theorise, based on these results, that early interventions by China may have played a role in index price fluctuations. As noted above however, the validity of current data in the early stages of a global pandemic must also be considered. We also theorise that the changing spatiotemporal nature of the virus also played a distinct role in index price fluctuations. Given the ongoing nature of the current pandemic, and the further shift in epicentre location to South America and India, our latter theory can be addressed through further research.

Appendix

See Tables 8–11.

Table 8
Volatility indices.

Country		Index
	China	CBOE China ETF Volatility Index (VXFXI)
	Italy	EURO STOXX 50 Volatility Index (VSTOXX)
	Spain	EURO STOXX Volatility Index (VSTOXX)
	UK	EURO STOXX Volatility Index (VSTOXX)
	USA	CBOE DJIA Volatility Index (VXD)
	World	CBOE Volatility Index (VIX)

Table 9
Overnight indexed swap rates.

Country		Index
	China	SHIBOR Fixing Overnight Index Rate
	Italy	Euro Overnight Index Average (EONIA)
	Spain	Euro Overnight Index Average (EONIA)
	UK	Sterling Overnight Index Average (SONIA)
	USA	Effective Federal Funds Rate
	World	Effective Federal Funds Rate

Table 10
Interbank offered rates.

Country		Index
	China	Shanghai Interbank Offered Rate (SHIBOR)
	Italy	Euro Interbank Offered Rate (EURIBOR)
	Spain	Euro Interbank Offered Rate (EURIBOR)
	UK	London Interbank Offered Rate (LIBOR GBP)
	USA	London Interbank Offered Rate (LIBOR USD)
	World	London Interbank Offered Rate (LIBOR USD)

Table 11
Other rates.

Country		Index
	3M Bond	Yield on 3M Generic Government Bond
	Gold	Brent Crude Oil (C01) Bloomberg
	Oil	Spot Price of Gold (XAU) Bloomberg

References

Akyildirim, E., Corbet, S., Efthymiou, M., Guiomard, C., O'connell, J.F., Sensoy, A., 2020. The financial market effects of international aviation disasters. Int. Rev. Financ. Anal. 101468.

Al-Awadhi, A.M., Al-Saifi, K., Al-Awadhi, A., Alhamadi, S., 2020. Death and contagious infectious diseases: Impact of the covid-19 virus on stock market returns. J. Behav. Exp. Finance 100326.

Ali, M., Alam, N., Rizvi, S.a. R., 2020. Coronavirus (covid-19)–an epidemic or pandemic for financial markets. J. Behav. Exp. Finance 100341.

Ashraf, B.N., 2020. Stock markets' reaction to covid-19: Cases or fatalities?. Res. Int. Bus. Finance 101249.

Avalos, F., Zakrajšek, E., 2020. Covid-19 and sars: What do stock markets tell us?.

Baker, S.R., Bloom, N., Davis, S.J., Kost, K.J., Sammon, M.C., Viratyosin, T., 2020. The unprecedented stock market impact of covid-19. Natl. Bureau Econ. Res..

Bank of England, 2020a. Interim financial stability report - uk financial stability and the covid-19 pandemic.

Bank of England, 2020b. Monetary policy report.

Baur, D.G., Lucey, B.M., 2010. Is gold a hedge or a safe haven? An analysis of stocks, bonds and gold. Financ. Rev. 45 (2), 217–229.

Bearman, G., Pryor, R., Vokes, R., Cooper, K., Doll, M., Godbout, E.J., Stevens, M.P., 2020. Reflections on the Covid-19 Pandemic in the USA: Will We Better Prepared Next Time? Elsevier.

Boudt, K., Paulus, E.C., Rosenthal, D.W., 2017. Funding liquidity, market liquidity and ted spread: A two-regime model. J. Empir. Financ. 43, 143–158.

Brainerd, E., Siegler, M.V., 2003. The economic effects of the 1918 influenza epidemic.

Bruce, A., James, W., 2020. U.K. coronavirus deaths rise by 27%. Reuters.

Brunnermeier, M.K., 2009. Deciphering the liquidity and credit crunch 2007-2008. J. Econ. Perspect. 23 (1), 77–100.

Campbell, J.Y., Grossman, S.J., Wang, J., 1993. Trading volume and serial correlation in stock returns. Q. J. Econ. 108 (4), 905–939.

Campbell, J.Y., Shiller, R.J., 1988. The dividend-price ratio and expectations of future dividends and discount factors. Rev. Financ. Stud. 1 (3), 195–228.

Chen, M.-H., Jang, S.S., Kim, W.G., 2007. The impact of the sars outbreak on taiwanese hotel stock performance: An event-study approach. Int. J. Hosp. Manag. 26 (1), 200–212.

Citi Market Insights, 2020. What does the coronavirus mean for investors? Citi.

Coburn, B.J., Wagner, B.G., Blower, S., 2009. Modeling influenza epidemics and pandemics: Insights into the future of swine flu (h1n1). BMC Med. 7 (1), 1–8.

Collins, C.G., Gagnon, J.E., 2020. A Timeline of Central Bank Responses To the Covid-19 Pandemic. Peterson Institute for International Economics (PIIE).

Corbet, S., Larkin, C., Lucey, B., 2020. The contagion effects of the covid-19 pandemic: Evidence from gold and cryptocurrencies. Finance Res. Lett. 101554.

Cullen, P., 2020. Coronavirus: Number of Cases more than Doubles in Single Day. The Irish Times.

Da Cunha, A.J.L.A., De Magalhães-Barbosa, M.C., Lima-Setta, F., De Andrade Medronho, R., Prata-Barbosa, A., 2017. Microcephaly case fatality rate associated with zika virus infection in Brazil: Current estimates. Pediatr. Infect. Dis. J. 36 (5), 528–530.

Dawood, F.S., Iuliano, A.D., Reed, C., Meltzer, M.I., Shay, D.K., Cheng, P.-Y., Bandaranayake, D., Breiman, R.F., Brooks, W.A., Buchy, P., 2012. Estimated global mortality associated with the first 12 months of 2009 pandemic influenza a h1n1 virus circulation: A modelling study. Lancet Infect. Dis. 12 (9), 687–695.

Decambre, M., 2020. How the Stock Market Has Performed During Past Viral Outbreaks. MarketWatch.

Del Giudice, A., Paltrinieri, A., 2017. The impact of the arab spring and the ebola outbreak on African equity mutual fund investor decisions. Res. Int. Bus. Finance 41, 600–612.

Delisle, J., 2003. Sars, greater china, and the pathologies of globalization and transition. Orbis 47 (4), 587.

Ecdc, 2020. Control, E.C.F.D.P.A. ed. European Centre for Disease Prevention and Control.

Egan, M., 2020. Oil Crashes By Most Since 1991 As Saudi Arabia Launches Price War. CNN.

Federal Reserve, 2020. Statement Regarding Repurchase Operations. Federal Reserve Bank of New York.

Florackis, C., Kontonikas, A., Kostakis, A., 2014. Stock market liquidity and macro-liquidity shocks: Evidence from the 2007–2009 financial crisis. J. Int. Money Finance 44, 97–117.

Gandel, S., 2020. Coronavirus Has Cost Global Stock Market $16 Trillion in Less than a Month. CBS News.

Garrett, T.A., 2008. Pandemic economics: The 1918 influenza and its modern-day implications. Fed. Reserve Bank St. Louis Rev. 90.

Goodell, J.W., 2020. Covid-19 and finance: Agendas for future research. Finance Res. Lett. 101512.

Gormsen, N.J., Koijen, R.S., 2020. Coronavirus: Impact on stock prices and growth expectations. University of Chicago, Becker Friedman Institute for Economics Working Paper (2020-22).

Harrison, S., 2020. Coronavirus: Sharp Drop in Irish Growth Rates. BBC News.

He, M., Li, L., Dehner, L.P., Dunn, L., 2020. Cremation based estimates suggest significant under-and delayed reporting of covid-19 epidemic data in wuhan and China. medRxiv.

Ichev, R., Marinč, M., 2018. Stock prices and geographic proximity of information: Evidence from the ebola outbreak. Int. Rev. Financ. Anal. 56, 153–166.

Imf, 2020a. Global Financial Stability Report. International Money Fund.

Imf, 2020b. World Economic Outlook Report: A Crisis Like No Other, an Uncertain Recovery. International Monetary Fund.

Khan, A., Naveed, M., Dur-E.-A.hmad, M., Imran, M., 2015. Estimating the basic reproductive ratio for the ebola outbreak in liberia and sierra leone. Infect. Dis. Poverty 4 (1), 13.

Khanna, R.C., Cicinelli, M.V., Gilbert, S.S., Honavar, S.G., Murthy, G.S., 2020. Covid-19 pandemic: Lessons learned and future directions. Indian J. Ophthalmol. 68 (5), 703.

Kilian, L., Park, C., 2009. The impact of oil price shocks on the us stock market. Internat. Econom. Rev. 50 (4), 1267–1287.

Liu, H., Manzoor, A., Wang, C., Zhang, L., Manzoor, Z., 2020. The covid-19 outbreak and affected countries stock markets response. Int. J. Environ. Res. Public Health 17 (8), 2800.

Loh, E., 2006. The impact of sars on the performance and risk profile of airline stocks. Int. J. Transp. Econ./Riv. Int. Econ. Trasp. 40, 1–422.

Masson, R., Winter, J., 2020. Energy and Environmental Policy Trends: Addressing the Threat of Covid-19 and the Oil Price War in the Petroleum Sector, Vol. 13. The School of Public Policy Publications.

Morales, L., Andreosso-O'callaghan, B., 2020. Covid19: Global stock markets "black swan".

Nippani, S., Washer, K.M., 2004. Sars: a non-event for affected countries' stock markets? Appl. Finan. Econ. 14 (15), 1105–1110.

Oler, D.K., Harrison, J.S., Allen, M.R., 2008. The danger of misinterpreting short-window event study findings in strategic management research: An empirical illustration using horizontal acquisitions. Strateg. Organ. 6 (2), 151–184.

Platt, E., Noonan, L., Fontanella-Khan, J., Rennison, J., Kruppa, M., 2020. Dash for Cash: Companies Draw $124bn from Credit Lines. Financial Times.

Poletto, C., Pelat, C., Levy-Bruhl, D., Yazdanpanah, Y., Boelle, P., Colizza, V., 2014. Assessment of the middle east respiratory syndrome coronavirus (mers-cov) epidemic in the middle east and risk of international spread using a novel maximum likelihood analysis approach. Eurosurveillance 19 (23), 20824.

Poshakwale, S.S., Chandorkar, P., Agarwal, V., 2019. Implied volatility and the cross section of stock returns in the UK. Res. Int. Bus. Finance 48, 271–286.

Powell, J., 2020. Interview on 60 minutes.

Ramelli, S., Wagner, A.F., 2020. Feverish stock price reactions to covid-19.

Rosillo, R., Giner, J., De La Fuente, D., 2014. The effectiveness of the combined use of vix and support vector machines on the prediction of s&p 500. Neural Comput. Appl. 25 (2), 321–332.

Sakaki, H., 2019. Oil price shocks and the equity market: Evidence for the s&p 500 sectoral indices. Res. Int. Bus. Finance 49, 137–155.

Sanche, S., Lin, Y.T., Xu, C., Romero-Severson, E., Hengartner, N., Ke, R., 2020. Early release-high contagiousness and rapid spread of severe acute respiratory syndrome coronavirus 2.

Sansa, N.A., 2020. The impact of the covid-19 on the financial markets: Evidence from china and USA. Electron. Res. J. Soc. Humanit. 2.

Sarkar, A., 2009. Liquidity risk, credit risk, and the federal reserve's responses to the crisis. Financial Mark. Portfolio Manag. 23 (4), 335–348.

Schrimpf, A., Shin, H.S., Sushko, V., 2020. Leverage and Margin Spirals in Fixed Income Markets During the Covid-19 Crisis. Bank for International Settlements.

Sengupta, R., Tam, Y.M., 2008. The Libor-Ois Spread As a Summary Indicator. Monetary Trends.

Shmueli, G., 2010. To explain or to predict? Statist. Sci. 25 (3), 289–310.

Stevens, P., Fitzgerald, M., Imbert, F., 2020. Dow Jones Tanks 2,300 in Worst Day Since Black Monday. CNBC Markets.

Thornton, D.L., 2009. What the Libor-Ois Spread Says. Economic Synopses.

Towers, S., Brauer, F., Castillo-Chavez, C., Falconar, A.K., Mubayi, A., Romero-Vivas, C.M., 2016. Estimate of the reproduction number of the 2015 zika virus outbreak in barranquilla, colombia, and estimation of the relative role of sexual transmission. Epidemics 17, 50–55.

Who, 2003. Consensus Document on the Epidemiology of Severe Acute Respiratory Syndrome (Sars). Department of Communicable Disease Surveillance and Response ed. World Health Organization.

Who, 2019. Middle East Respiratory Syndrome Coronavirus (Mers-Cov). Mers Monthly Summary November 2019. Department of Communicable Disease Surveillance and Response, World Health Organisation.

Who, 2020a. Coronavirus Disease (Covid-19) Outbreak: Who Announces Covid-19 Outbreak a Pandemic. World Health Organization.

Who, 2020b. Ebola virus disease. In: Department of Communicable Disease Surveillance and Response Ed. World Health Organization.

Zhang, D., Hu, M., Ji, Q., 2020. Financial markets under the global pandemic of covid-19. Finance Res. Lett. 101528.